1: Pelzer S-5 (1940-1941) 1945 AL1 Southeast Asia AL1

recuperate quickly when the area is again allowed to revert to bush."[38]

Several of the forest services of Southeastern Asia have made a rather successful use of the shifting cultivator in their endeavor to reforest the land. They have combined shifting culture and silviculture by hiring shifting cultivators to cut mature trees and to sow or plant new trees on cut-over or burned-over land. For this the cultivators are paid a small wage. In addition they are allowed to grow their own crops for one or two years between the rows of young trees. This system, known as the "taungya forestry system," was developed in 1856 by the German forester, Dietrich Brandis, while he was Superintendent of Forests in Pegu, Burma.[39] It is ingenious in that it recognizes the habits of the shifting cultivator and fits them into a modern forest economy instead of persecuting the cultivator and forcing him to give up his traditional culture. This system has been used in the teak forests of Java since 1871. The forest service makes a contract[40] with the peasants of Java according to which the peasants are to prepare the land and plant and take care of teak trees (*Tectona grandis* L.) in return for a small sum of money and the right to plant such crops as maize and red pepper (*Capsicum annuum* L.) between the rows of teak. The cultivation of upland rice is discouraged, and the planting of cassava, peanuts, castor beans, and tobacco usually is not allowed (Figs. 40, 41).

The taungya forestry system is an excellent way of getting pure stands of commercial timber. The typical forest of the tropics is expensive to exploit because of the large variety of trees which it contains, many of which have little or no commercial value.[41]

As important as reforestation is soil erosion control. Where shifting cultivation is practiced in mountainous regions it often causes such acceleration in the rate of erosion that the rivers are choked with sediment and periodically do great flood damage. Flood control could be achieved in most cases by completely closing the headwaters and watershed areas to cultivators. On more gentle slopes the clearings should be rather narrow, should parallel the contours, and be separated by belts of forest. If at the same time the forest uphill were protected by fireguards, the clearings would have a chance to close quickly again so that the soil would be

[38] Worthington: Science in Africa, 1938, pp. 378–379.

[39] *Taungya* is the Burmese term for the temporary field of the shifting cultivator, a term that the foresters have adopted. E. P. Stebbing in his work, The Forests of India, Vol. 1, 1922, p. 376, writes:

"Brandis, moreover, recognized that the very system which, till then, had destroyed teak forests might be utilized to produce them, . . . and as early as 1856 an attempt was made in Prome district to sow teak in regular rows, together with the rice scattered by the taungya [*sic*] cutters. Twenty years afterwards this attempt had grown into a regular system, by which areas were being annually stocked with teak at a cost far below that of regular plantations." See also *Ibid.*, Vol. 3, 1926, pp. 415–428.

[40] Becking: "De djaticultuur op Java," 1928, pp. 50–52.

[41] Heske: "Der tropische Wald," 1939, p. 414. Heske's article gives an excellent short account of the forests of Southeastern Asia and points out that they are on the whole much easier to exploit than are the forests of tropical America because of the abundance of cheap labor.

245 [654] 185 [313] 134 133 185 [See p. 41; cat III - Analyst]

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protected against abnormal erosion. Terracing would be the most effective method of checking soil erosion, but this requires a good deal of labor, which is scarce in areas of shifting cultivation.

The Forestry Service of the Indies started an interesting soil-erosion experiment near Tjiwidej in the mountains south of Bandoeng at an elevation of 1800 meters. Two adjacent parcels of forest land, lying on rather steep slopes, are drained separately—out of each parcel comes a little brook—and thus form separate drainage units. Both parcels were used by shifting cultivators who had cut and burned the forest. In one case the slope was left undisturbed; in the other the slope was terraced. At the foot of each slope catch basins were constructed to retain the sediment that was washed down by rain water and transported by the brooks. The amount of water that drains out of each unit was measured and the sediment weighed. The purpose of this experiment was to get quantitative measurements of the amount of erosion that is caused by shifting cultivation and to study the effect of terracing in reducing soil loss. During the first year both parcels lost very little soil, because the humus layer protected it; but in the second year the unterraced parcel lost 5.065 kg. of silt per square meter whereas the terraced parcel lost only one-half as much, or 2.524 kg.[42] (Figs. 42–45).

Under the conditions that we have discussed so far, no radical change in the system of cultivation is required. If, however, the population increases to such an extent that there is no longer enough available land to allow for a sufficiently long rotation cycle, more drastic remedies are necessary.

Such a situation arose in parts of the Outer Islands and attracted the attention of government specialists. Legal experts familiar with Indonesian customary law, foresters, and agricultural advisers collaborated to seek a solution.[43] Realizing that shifting cultivators are usually reluctant to give up their traditional form of land use, the specialists approached the ladang problem by searching for means of reforesting ladangs quickly. Experiments were made with the planting of quick-growing leguminous and non-leguminous trees, bushes, and shrubs to shorten the fallow period, restore the humus, protect the soil against accelerated erosion, eliminate the grasses, and, in the case of leguminous species, improve the soil by adding nitrogen.[44] We have already seen, however, that artificial refor-

[42] I was able to visit the Tjiwidej experiment with Mr. L. Gonggrijp, under whose supervision the work was carried out. For a detailed report on the project see Gonggrijp: "Het erosie-onderzoek," 1941, pp. 200–220.

[43] H. J. Friedericy of the Department of the Interior and H. Vonk and E. J. Wind of the Department of Economic Affairs, for example, worked together on the problem of ladang culture in the residency of Palembang.

[44] Experimental plantings included, among others, *Erythrina lithosperma* Miq., a light-loving tree which is typical in Southeastern Asia of dry, rather open climax forests and of second-growth forests; *Hibiscus tiliaceus* L.; *Albizzia falcata* Backer, one of the fastest-growing trees of Southeastern Asia, used widely as a shade tree on coffee plantations; *Aleurites moluccana* Willd., a tree at home in the drier parts of the East Indies; *Leucaena glauca* Benth.; *Pterocarpus indicus* Willd., a large tree frequently used along roadsides as

1 [see p. 42, category 16 -- Analyst]

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estation is not a discovery of Western-trained scientists but has long been practiced by certain groups in Southeastern Asia. It was the plan of the government to spread and enforce this practice of artificial reforestation wherever advisable. This practice, whereby the cultivator determines the vegetative cover during the fallow period instead of abandoning the ladang to chance growth, brings him to a transition stage between shifting cultivation and permanent cultivation. From there the step to permanent cultivation with crop rotation is but a short one.

Permanent cultivation requires repeated tilling and therefore more labor and tools than the shifting cultivator is accustomed to. Work animals are also desirable. An important obstacle to intensification of agriculture in wide areas of Southeastern Asia, however, is the fact that hill and mountain regions [up to about 1500 meters in elevation] are frequently infested with malaria so that the energy of the people is greatly reduced.[45] Moreover, the acquisition of such implements as plows, harrows, and hoes, and especially of work animals, calls for financial resources or credit, both of which the average shifting cultivator lacks. Some shifting cultivators do own livestock, such as cattle or carabaos, but utilize neither their labor nor their manure. Groups of the Mois in the mountains of Annam have carabaos, but they do not use the animals in their agricultural activities because they "cannot talk" to them.[46] On the Lesser Sunda Islands livestock is kept because it gives social prestige to the owner. Overstocking of the pasture areas on these islands has led to overgrazing and has cut into the forest area until there has developed a scarcity of land suitable for ladang cultivation. The same has happened in large areas in Africa. There it has been necessary to teach the native peasant the use of cattle and make him familiar with the plow. This was done successfully in northern Nigeria by combining the animal husbandry of the nomadic Fulani with the indigenous shifting cultivation of the Hausa peasant, thus developing "a system of permanent farming whereby a man with cattle of his own, say two working oxen and a few cows, can plough and maintain in fertility an area of land sufficient to supply all the requirements of himself and his family, and to obtain a surplus balance as a return for his labour. . . . Thus mixed farming represents a gradual evolution from the shifting methods of cultivation to a static type of agriculture, by the introduction of animal husbandry, and with the use of animal cultivation."[47] Above all, the peasant learns to preserve the animal manure and

a shade tree; *Dolichos lablab* L., a climbing herb which is valuable as a vegetable; *Crotolaria anagyroides* H.B. and K., a bush of vigorous growth which attains a height of from 12 to 14 feet and forms an excellent green manure; *Tephrosia candida* DC. and *Tephrosia vogelii* Hook., low shrubs useful as green manures; and *Mimosa invisa* Mart., a leguminous creeper which suppresses grasses.

45 Gourou: L'utilisation du sol, 1940, pp. 181 and 350.

46 *Ibid.*, p. 354.

47 King: "Mixed Farming in Northern Nigeria," 1939, p. 271. See also Faulkner and Mackie: West African Agriculture, 1933; and by the same authors: "The Introduction of Mixed Farming in Northern Nigeria," 1936, pp. 89–96.

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FIGS. 22 and 23 illustrate undesirable conditions that may result from shifting cultivation.

FIG. 22—*Cogonales* cut and burned out in a valuable commercial forest before the holder of the timber concession had a chance to exploit it. Negros Occidental Province, Negros. (Courtesy of the Bureau of Forestry.)

FIG. 23—*Cogonales* in the foreground and patches of second-growth forest in the hills. The *cogon* is gaining the upper hand because of repeated fires, which prevent natural reforestation. Near Port Banga, Zamboanga Province, Mindanao. (Courtesy of the Bureau of Forestry.)

FIG. 24—Filipino foresters investigating the extensive *cogonales* of eastern Nueva Ecija Province, Luzon. (Courtesy of the Bureau of Forestry.)

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Chapter One

THE NATURAL LANDSCAPE OF SOUTHEAST ASIA

101 131 103 SOUTHEAST ASIA is a term which became popular during the Far Eastern War 1941-45, to describe those territories of Eastern Asia which lie south of the Tropic of Cancer (Burma, Siam, Indochina and Malaya) and the nearby islands spreading eastwards from the Asiatic continent towards New Guinea. The archipelago section merges eastwards into island groups of the West-Central Pacific, for which reason New Guinea itself may best be considered outside the definition "Southeast Asia," an exclusion justified (*a*) by its closer physical association with the Australian Continent, (*b*) by its sparse population of distinctive anthropological type now found principally in Australia, and (*c*) by the close affinities of its flora and fauna with those of Australia. The northern limit of Southeast Asia extends beyond the Tropic of Cancer to include Upper Burma on the western side, and withdraws south of the tropic to the political boundaries of Siam and Indochina farther east. By this definition, "Southeast Asia" and its off-lying islands sprawl asymmetrically across the Equator and cover a zone not far short of 1,500 miles in radius from a point off the mouth of the Mekong, an area comparable to all Europe and its seas north of the African coast. Thus isolation by great distances, as well as by physical obstructions, is a constant factor in the geographical relation between the various parts of Southeast Asia.

133 In Southeast Asia, that which forms its core and constitutes the geological link between its chief parts is the Sunda Platform, the southernmost continental block of Asia, whose integrity as a land mass has continued, with only minor tectonic disturbances on its fringes, through such long geological periods that it may be compared with those other "permanent" massifs, the Deccan, the Arabian Block and the Laurentian Shield. It is this physical feature which underlies Borneo, Eastern Sumatra, Northern Java and Malaya.

A somewhat similar platform is the common physiographic basis of Australia and New Guinea, forming what is known as the Sahul Shelf, to the east of the East Indian Archipelago.

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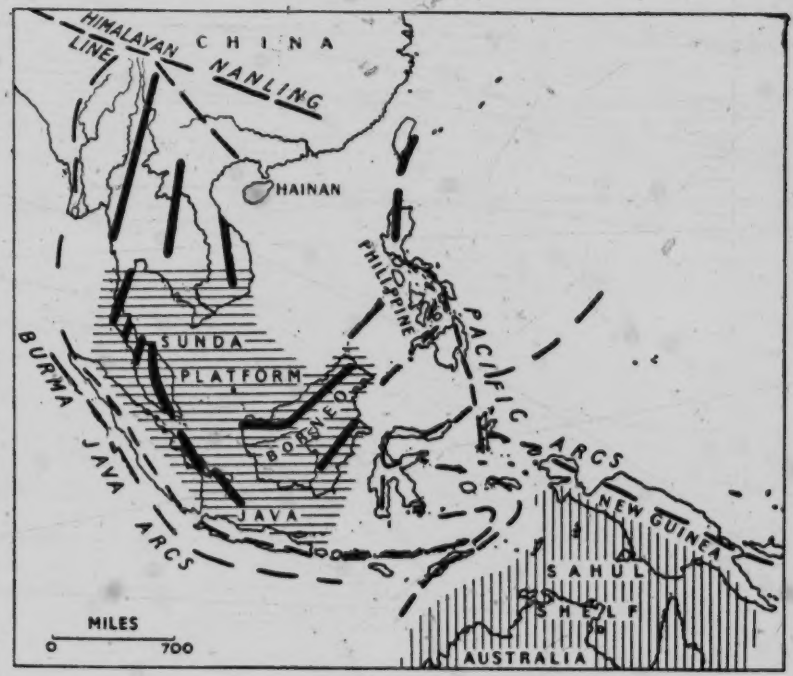

FIG. 1.—Landforms of Southeast Asia

The three basic physical units (Fig. 1) of this region are, then:

1. The Sunda Platform
2. The Sahul Shelf
3. A "ground swell" of young mountain arcs fringing and lying between the two other units.

1. THE SUNDA PLATFORM

The line of the Himalayan mountain formations extends eastwards to the China Sea to appear in South China as the Nanling and as that line of W-E. mountains forming the watershed between the Red River of Tonkin and the Sikiang of Canton. This chain of fold mountains of Alpine type delimits Southeast Asia geologically from the rest of Asia and is accepted as evidence of mountain building processes related to forces operating from the north.

South of this marginal zone of latitudinal alignments, the structural trends, although varying from place to place, are mainly meridional and modulate the surface of the Sunda Platform itself

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on similar lines. These roughly N-S. ranges are described by Suess as the roots of ancient mountains. They are to be thought of as the denuded vestiges of mountain systems, the inner crystalline cores of which stand revealed by prolonged erosion of the sedimentaries within whose folds they were primarily intruded. These stumps of mountains are typically free from precipices and crags, have gentle slopes but are still fairly high because the parent mountains were huge, probably of Himalayan proportions. Today these "Altaid" relief features, apparent in that mountainous

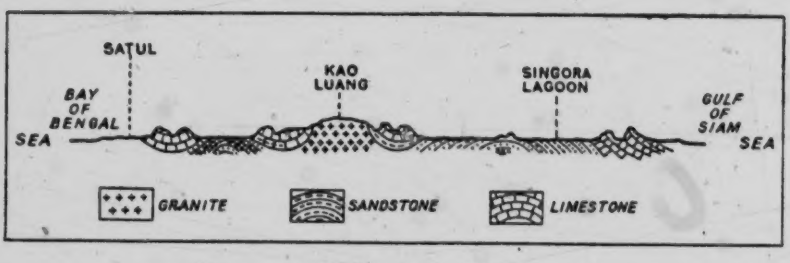

FIG. 2.—A Section of the Kra Isthmus

country between Burma and Siam, in Indochina, in Malaya and in Borneo, by no means approximate to the towering heights of Himalayan and Alpine mountains, having been denuded to little higher than some 10,000 ft.

Towards the centre of the Platform, in Malaya and Borneo, the characteristically senile, denuded relief (Fig. 2) is most emphatic, extending into the islands of the Lingga and Rhio Archipelagoes, which may be considered as monadnocks. The Altaid trend lines, while mainly meridional, are least so in Borneo, where NE-SW. alignments are apparent. In Indochina, Siam and the Kra Isthmus, the N-S. line is well developed and very pronounced in that closely packed series of ranges among which the Irrawaddy, Salween, Menam, Mekong and Red Rivers have parallel courses. While the Sunda Platform has had a prolonged history of stability, at the present moment it is extensively inundated, so that only its higher parts stand above sea level. The advanced peneplainisation of the Platform as a whole is evidenced by the uniformity in depth of the shallow seas, the South China Sea, Malacca Strait and Java Sea, now spread across the continental shelf.

The Sunda Platform is characteristically free from volcanic

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phenomena of any except very remote geological periods and it is not subject to earthquakes.

2. The Sahul Shelf

Similar to the Sunda Platform in its morphology, the Sahul Shelf is best considered as a northern extension of the Australian continental mass, partially inundated by the shallow Arafura Sea, and terminating south of the main E-W. range of middle New Guinea. This stable land mass is, like the Sunda Platform, free of recent volcanic forms. Evidence of active mountain building on its fringe, in the north of New Guinea, suggests stresses from the Sahul Shelf towards the north.

3. Young Mountains and Insular Arcs

The festoons of mountains which enfold the Sunda Platform and the Sahul Shelf provide much scope for theories about mountain building processes, a matter outside the immediate field of geography. These mountains in many cases rise steeply from the floor of the Indian and Pacific Oceans to heights over 15,000 feet above sea level; in other localities, the greater part of the mountain system is below sea level and only its topmost points emerge as strings of islands. Fault and fold systems on several lines curve and recurve over one another to make an exceptionally involved pattern, in which certain well marked alignments may be distinguished.

(*a*) The Burma-Java loop starts from the India-Burma border and runs through the Arakan Yoma, disappears for some distance as a topographic feature and then continues as the complicated fold-fault systems of Western Sumatra, South Java and eastwards as a string of islands curving back from the Sahul Shelf through the Kei Islands to Ceram. This series on the Indian Ocean fringe of Southeast Asia is paralleled seaward first by a deep oceanic trough and then by an oceanic ridge showing as the Nias-Mentawei Islands off West Sumatra and as the islandless submarine ridge south of Java.

(*b*) The arcs on the Pacific margins run through the Philippines and Northern New Guinea, creating lines of islands enclosing small, deep, square-shaped, oceanic basins. Troughs or trenches much deeper than the Pacific average are situated on the Pacific side of these arcs (the Philippine Trench is over

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7 miles deep), and these resemble in form and location the oceanic trenches off Sumatra and Java. 133

(*c*) The complex of short arcs and knots showing in the Celebes-Moluccas groups have alignments which repeat the patterns of the Pacific and Indian Ocean fringes, and of the inner edges of the Sunda Platform and the Sahul Shelf. Here, too, the arcs

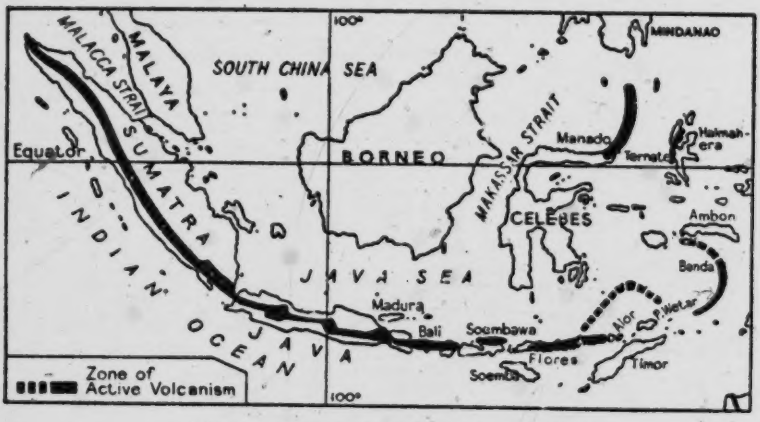

FIG. 3.—East Indies Volcanic Zones

enclose deep geosynclinal oceanic basins, such as the Molucca Sea which is over 16,500 ft. deep. The intersection of these alignments produces the curious shapes of Celebes and Halmahera. This zone may be likened to the "mediterranean seas" between Europe and Africa and between North and South America; in this case it is a mediterranean sea between Asiatic and Australian continental blocks.

Throughout these zones of contemporary crustal deformation, the longitudinal and transverse fractures are dotted with volcanoes, many of which are still active (Fig. 3). Their ejecta further complicate the land forms already made complex by the ravages of violent erosion (Fig. 4). Lava and igneous materials of widely varying ages have flowed over large areas and even on to parts of the Sunda Platform, as in Sumatra. Within the oceanic deeps marginal to these zones of crustal stress are the epicentres of most of those major earthquakes whose frequency is yet another symptom of the instability surrounding the shelves.

Thus the geomorphology of this third zone is transitional,

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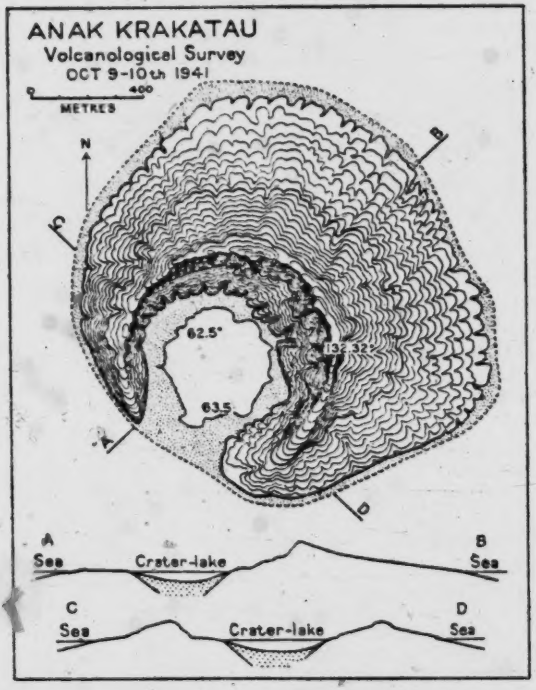

FIG. 4.—Detail of a Volcanic Island in the East Indies

reflecting at once the influence and forms of continental Asia and continental Australia, and of the Indian and Pacific Oceans.

ROCK TYPES

135 133 Profound chemical action caused by tropical and equatorial weathering has two effects on most of Southeast Asia; the destruction of readily accessible fossils by weathering and the concealing of native rocks by great thicknesses of weathered material. Thus the historical geology of Southeast Asia, the dating of the rocks, is not yet fully studied, and the geological interpretations of local rocks are by no means unanimous.

So far as their general character is concerned, however, no appreciable difference can be noted between the rocks of Southeast Asia and those of more intensively studied areas in Europe and North America. The effects of each rock type in conditioning landscape forms appear to be much the same throughout the world, differing in degree, not in character.

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The pattern of rock types may be summed up thus:

1. Within the Sunda Platform quartzites and shales are prominent over large areas, generally producing subdued relief, not closely allied to the fold lines of the strata. These metamorphics often appear at the surface close to a group of limestone rocks of which a calcareous shale, much of it in areas of low elevation, is most extensive. Massive limestone is most common as a landscape feature where least subject to solution weathering,

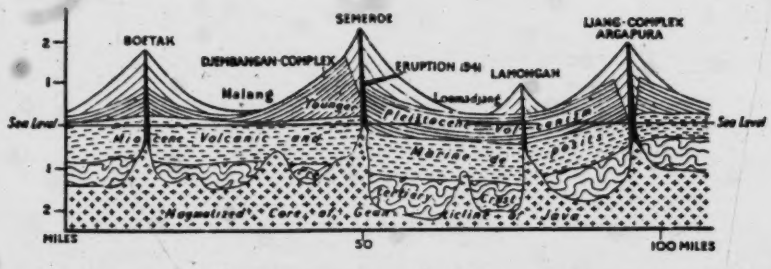

FIG. 5.—Schematic West-East Section of the Mountain Structures in Malang

towards the drier margins of the Platform (as in East Java and Tonkin) where it stands out as gaunt hills whose features recall those of the Karst, though partly disguised by a wilder profusion of vegetation. Small, slightly metamorphosed limestone formations retain this karstic character even under equatorial rains, as in North Malaya where they still rear prominently above the horizon. A large part of Borneo, the biggest single exposure of the Platform, is built of old sandstone, establishing a flat-topped landscape through which ravine-like valleys have been cut. The higher mountains of the Sunda Platform, the Altaids of Suess, are invariably elongated intrusions of igneous rock, mainly granitic, and this material forms the chief heights of a relief otherwise gently modulated.

2. Upon the young mountain systems marginal to the Platform, the landform owes more to recent tectonic activity than to the nature of the constituent rocks, most of which are also represented on the Sunda Platform. Complex fracturing and folding produce on the young mountains a wild steep landscape which here and there encloses fragments of older continental blocks. The vents and caldera of volcanoes (Fig. 5) add their special forms built from looser, easily eroded rock materials of lava

133 135 type which have been severely scarred by denudation. Magmatic rocks have flowed extensively from these volcanoes, spreading over a large area and serving to mask relief forms developed upon underlying earlier structures. As a result of these igneous formations throughout the region, contact metamorphosis has taken place on a large scale, which has a major bearing on the frequency of metallic minerals and helps to account for the scarcity of coal formations.

133 134 3. The detail of much of the Southeast Asia landscape is conditioned by contemporary river alluviation and coastal sedimentation (as in Eastern Sumatra and South Borneo) whose thickness and profusion relate to the rapidity of tropical erosion on the one hand and to the stability of the continental platform on the other. Relief upon the great alluviated landscapes is slight. In this zone where there is so much coastline in proportion to the land area, marine accumulations of spits, bars and off-shore beaches are both prominent and important in conditioning coastal topography and the location of settlements. Marine loads tend to be heavy in this zone of violent terrestrial erosion and under certain conditions sediment accumulates quickly owing to the speed with which mangrove establishes itself upon any bank or spit which is built up, thereafter further hastening deposition by hindering the free scouring of normal wave action. Marine sedimentation is greater upon the inner coasts of the Sunda Platform and less upon those coasts facing the Indian and Pacific Oceans where the shore profiles are steep and the waves have maximum fetch.

Character of Seas

133 Three types of seas may be distinguished by the criterion of depth:

1. Shallow seas of the Sunda Platform
2. Shallow seas of the Sahul Shelf
3. The Austro-Asiatic "mediterranean" basins between the Sunda Platform and the Sahul Shelf, and subdivided by island festoons. In this group may be provisionally placed the Sulu Basin, though the South China Basin between the Philippines and the Asiatic mainland may only be included by considerably stretching the "mediterranean" conception.

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1. *Sunda Platform Seas*

These seas, the Malacca Strait, the southern portion of the South China Sea, the Sunda Sea and the Java Sea, are remarkable less for their shallowness than for the uniformity of their shallowness, which is mostly about 120 ft. and only in a few places reaches depths exceeding 150 ft. This derives from the long history of peneplainisation of the whole platform prior to its present partial inundation, which has fairly conclusively been shown to be due to eustatic rather than tectonic changes. The small islands (the Rhio, Lingga, Banka and Billiton islands) within these seas are generally of monadnock type and they have granitic cores. Low profiles characterise the adjoining shore lines where broad estuaries carry low topography far inland and where flat coasts of sedimentation, backed by marshes, are more common than those of marine erosion. Such shallow seas are affected strongly by currents arising from winds and less by the circulatory systems of the surrounding oceans, so that monsoonal wind reversals are the major influences on water movement. The drift of surface water thus relates closely to the wind systems described in Chapter 2. Out of contact with oceanic circulations by reason of the disposition of islands athwart the lines of Indian and Pacific Ocean water movements, and located between equatorial land-masses with a very heavy rainfall draining into them, these shallow seas are abnormally fresh and remain abnormally warm: from salinities of 31 per mille and sea temperatures of 70° F., few parts of the surface waters show any significant deviation from place to place or from season to season.

Enclosed between the Andamans, Burma, Kra and Sumatra is a sea steadily being encroached upon by the Irrawaddy Delta, yet its depth and connection with oceanic circulations external to the Platform relate it chiefly to the Bay of Bengal, except that the huge outpouring from Burmese rivers lowers its surface salinity to figures even below those of the Platform seas.

Further evidence that the existence of these seas derives from eustatic rather than tectonic changes is found in the loose gravels, sands and muds which form most of the beds of Sunda Platform waters and in the absence of raised wave-cut terraces along the coasts. Attached plants may be found almost everywhere on the sea floor, which is entirely eulittoral in character.

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2. *The Sahul Shelf*

123 The Arafura Sea and its extension to the Gulf of Carpentaria have been only sketchily studied and are properly outside Southeast Asia. They broadly repeat the features of the Sunda Platform seas except that the salinities are not so abnormally low because the freshwater inflow is less abundant, since the Australian margin has a lower rainfall.

3. *The "mediterranean seas" of the Indies*

The Snellius Expedition catalogued twenty-six distinct basins and trenches in the 'mediterranean seas' of the Indies, excluding the deep between the Philippines and China which scarcely belongs to the region. Of these, eight are deeper than 15,000 feet while the sills between them are not less than 4,000 feet deep. Within each basin there tend to be two circulatory systems:

(*a*) the surface circulation, relatively fast-moving, connected freely with circulations in adjoining basins and thence with currents in the open ocean. It is confined to an upper layer reaching from the surface to approximately the depth of the sill surrounding the basin, that is, to an average depth of about 5,500 feet. The location of the main island barriers is such that the upper waters are strongly influenced by water from the North Equatorial Current of the Pacific, which presses into the 'mediterranean seas', through those many gaps between Mindanao and New Guinea. Scarcely any similar currents derive from the Indian Ocean, in the direction of which the basins are almost isolated by the continuous Sumatra-Java obstruction. In temperature, these basins have a surface warmth similar to that of all equatorial waters, the great difference between their surfaces and those of the Platform seas being a higher salinity—generally 34.5 per mille—and a diminished influence of monsoon winds.

(*b*) the circulation at depth, a movement so slow that the expression "creep" might be substituted. This movement takes place within each basin or trough, isolated from circulation in neighbouring deeps by the sill, and from the surface movements by a discontinuity plane which develops owing to the greater density of the deep water. For the most part, however, the water moving in these isolated deeps originates from the

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Pacific b· creeping into the Northern Banda Basin, then passing through the Southern Banda Basin and the Weber Deep, the Sawoi Basin and the Weker Basin out into the Indian Ocean deeps. All these lower waters have characteristically high salinity and low temperatures, which prevent any continued outward movement from the basins, though there is a steady removal of water drawn in from deep-level Pacific Equatorial water, whose feature is low temperature by comparison with adjoining water at the same depths within the sills. Inside the basins, minimum temperatures are found just below the level of the lowest sill. Farther down this temperature increases adiabatically but the potential temperature (i.e. reduced to sea level) remains low, so that no convectional circulation is induced. Under these conditions of dense water stably stratified, the profound deeps tend to accumulate hydrogen sulphide.

The margins of these 'mediterranean seas' commonly show raised beaches and wave-cut terraces uncorrelating in altitude from point to point owing to the wide variation of amplitude in the tectonic changes over short distances. Shore profiles are normally steep with the result that estuarial sedimentation is negligible.

Tides

Within these partially enclosed seas, the greatest tidal impulse comes from the Pacific, towards which broad openings are presented on either side of the Philippines. Only in the Gulf of Rangoon and in the funnel-shaped Malacca Strait do tidal forces from the Indian Ocean operate, though they do slightly filter through the gaps in the Lesser Sundas, the line of small islands between Java and New Guinea.

Tides in the deep basins and troughs of the mediterranean sector have not been studied in detail. They probably function as standing oscillations, whose periodicity depends on the form and size of the deeps.

Conditions on the Sunda Platform are better known because of their greater importance to international navigation. The tidal impulse comes to the shallow seas mainly from the east and whatever the character of tides in the open ocean or in the mediterranean basins, the impulse is converted into progressive waves by the shallowness of the seas upon the Platform (Fig. 6).

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FIG. 6.—Co-tidal Lines in Southeast Asia seas for 15th March 1947

From the west, tides from the Gulf of Rangoon Deep move down the funnel-shaped Malacca Strait, travelling somewhat faster on the Malayan side than on the Sumatran, and steadily increasing in range. From the east, there is firstly the tide from the Hongkong Basin, which is of Pacific origin, and secondly the tide in the Java Sea deriving from the southernmost 'mediterranean seas', which take their main impulse from Indian Ocean tidal movements, operating in the Timor Sea and through the Lesser Sundas. The South China Sea tide moves south through the Sunda Sea and travels through the Java Sea along the southern coast of Borneo, whereas the Northern Java coast is for some distance subject to a tidal movement from the east.

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Just west of Singapore Island, the Malacca Strait and the South China Sea tides converge, locally retarding the scouring capacity and apparently favouring heavy marine sedimentation derived from the adjoining land masses. Among the Lingga and Rhio Islands, the actual tidal movements are extremely complicated due to convergent tidal waves from neighbouring seas. Tidal values in all these seas are modified seasonally by winds which practically reverse through the year, working to augment or reduce the tides as the case may be. The South China Seas, whose length parallels the direction of the seasonal wind streams, is particularly subject to this modification in the Northeast Monsoon which very much affects the ease of tidal progression from that sea into the Java Sea.

Corals

The polyps and other organisms whose skeletons accumulate to form coral reefs, live in colonies which within four years may grow to two inches in diameter from a single individual. They are exacting in their environmental requirements, needing sea temperatures of at least 58° F. throughout the year, shallow clear water to permit their food processes, which are largely photosynthetic, and fairly high salinity. A live coral colony has a slimy surface which is in fact the living matter; the live cells die if exposed to the air, or if covered with mud. Corals establish themselves for the most part on rocky foundations. Off Southeast Asia distinct differences can be seen in their regional distribution.

On the Sunda Platform as a whole corals are only developed well beyond easy access from the shore. The relatively fresh seas with swampy margins heavily charged with fine silts and humic acids are unfavourable to the polyps and the recent history of slow inundation of the Platform operates against them as well, though corals are found at depth along its margins and in broad belts round the rocky islands off South Malaya. Platform corals are exclusively submarine and generally stand below sea level well offshore, so that they are never prominent on a coastal landscape. The great development of coral is on the eastern edge of the Platform, running parallel to the east coast of Borneo and well out into the Macassar Strait (Fig. 7), where broad reefs occur whose proportions resemble those of the Great Barrier Reef on the eastern edge of the Sahul Shelf. These locations are favourable because they are washed by the warm onshore equatorial currents;

132 is rendered even less by the high humidity which cuts off many actinic wavelengths. In Singapore over half the sunshine day is obscured by clouds; in Jakarta less than 70 per cent of the possible sunshine hours are sunny. A distinct diurnal rhythm of sunshine incidence is characteristic of the Equator; during the mornings, which frequently begin clear and sunny, cumulus clouds steadily increase to a maximum in the afternoon, when convectional influences are at their peak, often producing thunder-showers followed by a clearing of the sky towards sunset. The amount of sunshine received is normally greater at sea level and decreases with altitude. On the other hand, those districts with distinct dry seasons have high sunshine values in the dry periods, often offset on the average by prolonged obliteration of the sun during the rainy season. These factors have considerable agricultural significance.

Humidity

High average humidity values are normal everywhere in South-east Asia, but they are subject to frequent variations. Coasts are damper than interiors and highlands are damper than plains. Localities with marked dry seasons have periods of low humidity accompanied by high temperatures. In any one place a few hours sunshine rapidly lowers the relative humidity and it is a fact that even in the wettest places, the ground and wet clothes dry out under direct sunshine. Comparatively minor humidity variations have considerable effects on plants, and from the point of view of human beings it is the humidity rather than the temperature which produces feelings of body heat or body cold. When the relative humidity drops a few points, the skin sensation is one of coolness, due to easy evaporation of perspiration. By the same cause, a site exposed to regular breezes feels drier and cooler than the actual humidity or thermometer figures justify. The generalised rainfall and seasons map (Fig. 10) is a convenient guide to the distribution of humidity.

Altitude Effects

133 Throughout the region altitude is an important factor varying
132 the local weather conditions. While the land masses are relatively small, they are orographically very broken so that (apart from

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East Sumatra) no very extensive plains have developed and mountains are visible from most points. Even the highest peak known (Kinabalu, Br. Borneo, 13,681 ft.) lies well below the snow line but those highlands adjoining Yunnan do receive a brush of snow in winter. The average highland is, however, more

CHINA
Cw warm temperate rainy climate with at least ten times as much rain in wettest summer month as in driest winter month
Cf warm temperate rainy climate with no distinct dry season
Amw
SIAM
Aw tropical rainy climate with at least one month of dry season receiving less than 2·4" in that month
FR. INDO-CHINA
Amw tropical rainy climate with short dry season but total rainfall enough to support rain forest
PHILIPPINE IS.
Manila
SOUTH CHINA SEA
MALAYA
Afi
Singapore
BORNEO
Equator
Cf
Afi tropical rainy climate with no month receiving less than 2·4" rain and less than 9°F. difference between warmest and coldest months
CELEBES
Jakarta
JAVA
Awi tropical rainy climate with at least one month of dry season & less than 9°F. difference between warmest & coldest month
MILES
100 0 100 300 500

FIG. 15.—Köppen's Climatic Regions in Southeast Asia

of the order 8,000 feet and continuous areas at a high altitude are quite small. These altitudes induce local temperature reduction, more evident at night than during the day, and local high humidities. They cause local rain shadows which, owing to the differing winds through the year, are seasonal rather than permanent, except where double ranges give the intervening lowland a fairly constant rain shadow, as in Central Burma. A major function of the higher altitudes is to cause orographic rains and to lower the temperatures, which latter has less geographical significance than the overall raininess.

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Chapter Three

THE DRAINAGE PATTERNS OF SOUTHEAST ASIA

THE Irrawaddy, Salween, Menam Chao Praya and Mekong are remarkable for their length compared with most Southeast Asia rivers, which rarely exceed a few hundred miles long. Those four major rivers are associated with tectonic basins; relief elsewhere only permits short streams. All districts marginal to the Sunda Platform have experienced relatively recent tectonic changes and the rivers developed upon them are youthful as well as short. Upon the Platform itself much more advanced landscape maturity is evident but because this older surface has only limited areas exposed, rivers even there are short.

CHARACTERISTICS OF TROPICAL RIVERS

In the régime of tropical rivers several factors have distinctive emphasis compared with conditions in temperate latitude rivers. Firstly the volume of water precipitated into and to be carried from any drainage basin is several times that of equivalent temperate latitude rivers as a result of the much higher rainfall. Moreover the precipitation is more intense. Even the dry interior of Burma experiences falls of rain averaging ·6 inches per rainy day. The water content of those Tropical Air Masses over Southeast Asia is so high and the rising air currents so strong and sustained that several Javanese stations have recorded falls of over 16 inches per day. These violent torrential downpours are often very localised at any one time, yet on an average they affect large areas. Thus the volume of rainwater in any drainage basin is enormous and fluctuates widely within short periods of a few hours.

A further consequence of these great rainstorms is their powerful erosive effects. Upon cultivated land the force and volume of these downpours cause surface downwash to be large, the soil rapidly washes away and whole hillsides may slip, so that the run-off has a high mud content. Because the rivers are mostly immature, this heavy load may be sustained by turbulence for considerable

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distances. In areas of alternating wet and dry seasons, drought cracks the ground, loosens the top surface and thereby increases the available load when the rains begin. The Dry Zones of Burma and Siam are for this reason areas of most violent surface removal. The very heavy load of Southeast Asia rivers gives them a great capacity for rapidly building up deltas, sedimenting the estuaries and at times causing heavy deposition of silt well inland. Furthermore the rainfall is not only violent and intense, it is also variable in seasonal incidence; thus many streams of Upper Burma, Central Siam and Eastern Java are for months practically dry and then come into spate within a few hours, not unlike the wadis of North Africa. Landform combined with the seasonal rains causes the Salween, for instance, to vary its level 50 feet within a few hours. Such variability of volume induces deposition well inland. Huge silt banks lie across many watercourses, vast alluvial fans develop at the debouchment to plains, and even at the junction of tributaries.

The Irrawaddy presents an example of how the drainage conditions differ at different points in the course of a tropical river. Near and above Bhamo changes of Irrawaddy level directly parallel changes of rainfall. As the stream passes through the Dry Zone of Burma it receives no significant additional water from the tributaries after it passes the confluence of the Chindwin and it is effectively losing water by evaporation. Stamp estimates 45 per cent of Irrawaddy water has been lost by evaporation when the stream finally reaches the head of the Delta. Evaporation rates in the Burmese Dry Zone are little, if at all, less than the precipitation. Farther downstream, in the Delta, heavy precipitation occurs again, so that the Irrawaddy floods arrive at the Delta roughly a month after peak rains in the reaches above Bhamo, to find it already suffering from floods due to local rains and small local streams. These floods of local origin effectively oblige the Irrawaddy water to remain within the main distributaries. Even more interesting is Stamp's evidence that the average annual silt load at the Delta head is 261 million tons, whereas at Mandalay it is only 32 million tons, showing that 229 million tons of silt is added in the Dry Zone. Since the Chindwin provides 109 million tons of silt, the balance of 120 million tons derives from the wadi-like, highly variable streams (chaungs) joining the Irrawaddy in its driest section.

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Load and the Erosion of Basins

Acting as a brake on the destructiveness of the rivers and on the changes of river levels, the dense forest cover of most of the landscape breaks the force of the downpours and provides roots and undergrowth to act as a spongelike retainer of water and as a partial filter of sediment. Under natural conditions, where the forest is undisturbed by man, this influence is so strong that even minor brooks are relatively clear, but where the natural cover is removed by burning to permit cultivation or mining, the brooks are thick and opaque with sediment, a condition rapidly extending as more and more surface is exposed for farming or for alluvial mining. Wherever there are active volcanoes, great quantities of loose ash are thrown out regularly; Southeast Asia volcanoes typically eject ash rather than lava. Unconsolidated ash without vegetation cover is rapidly washed into the streams and by these agents spread out over the estuaries. A new volcanic outburst is at once followed by heavier loads in the local rivers and increased estuarial deposition (Fig. 19) and greater danger of silting up irrigation and drainage canals which may have been built downstream for cultivating rice. That so much of Java's volcanic ash cones are terraced may only partly be ascribed to agricultural pressure; the terracing is equally necessary to control slip of the ash and to prevent sedimentation by waterborne ash from completely overwhelming the lowlands. Largely as a result of heavy ash loads, the Solo River, for example, carries some sixty times as much sediment as the Rhine, though it has only 40 per cent of its length.

The heavy load being carried away by the rivers lowers the surface of the drainage basin over most of its area, even though part of the lower basin is being built up a little by sediment. The rate of destruction of the drainage basin in the tropics is far higher than anywhere else. The Chindwin is removing the surface of its basin by .78 mm. per annum, the Irrawaddy above Prome by .52 mm. per annum, the Loesi in Java by .87 mm. In some small Javanese streams the destruction of the drainage basin has reached as much as 3 mm. per annum. As standards of comparison, the annual lowering of the Danube basin is at the rate of .006 mm., and of the Marne, .005 mm.

As a region, Southeast Asia is thus one of the least stable in the world, as far as orographic form and drainage patterns are

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concerned. Erosion here works faster and the associated deposition occurs at a greater rate than temperate latitude geographers allow for. This adds only a further variant to the general tectonic instability of all the zone fringing the Sunda Platform, but in the case of the Platform itself, its great age and relative stability plus the intensity of river erosion, provide an excellent case of a landscape exposed continuously to subaerial erosion for a period long enough to indicate an approach to the peneplainised state. The Malayan landscape, central to this continental Platform and exposed fully to continuous, powerful and prolonged river action, has special interest in this connection. In Malaya, large alluviated plains dominate the landscape and the hills rise sharply from these plains, yet the features of normal river types still persist. Rapids exist in a number of Malayan rivers, profiles are slightly broken at a number of levels, trellis drainage patterns have persisted on tilted strata (Fig. 32) and river capture goes on even at this advanced stage, as in the capture of the Bera headwaters by the Muar (Fig. 16). Lakes, however, are unusual on the main Sunda Platform; this negative point is at once a symptom of erosional senility and of the ability of tropical vegetation to build out into the lakes, hastening their sedimentation until the standing water disappears. Thus the Bera Lake of Malaya is really a large swamp periodically inundated; the Tonle Sap of Indochina is rapidly filling to become a similar swamp-lake varying with the seasons. Infilled swamp-lakes appear also in Borneo and the Shan Plateau.

The Glacial Period and Southeast Asia Drainage

While tectonic and erosional changes have produced most variations in river forms of those parts of Southeast Asia fringing the Sunda Platform, *upon* the Platform itself, rivers have been more recently affected by a process of marine inundation. There is general agreement that the history of the Platform is one of stability or possibly of slight sinking; the uniform depth and terrigenous bottom material of the Sunda Platform seas, and also the fully-developed river valleys upon their floors, combine to support the view that a rise of sea level has taken place, associated with continental icemelt which took place in northern latitudes when the last Glacial Period closed. De Geer estimates that the last Scandinavian glaciation reached its peak some 25,000 years

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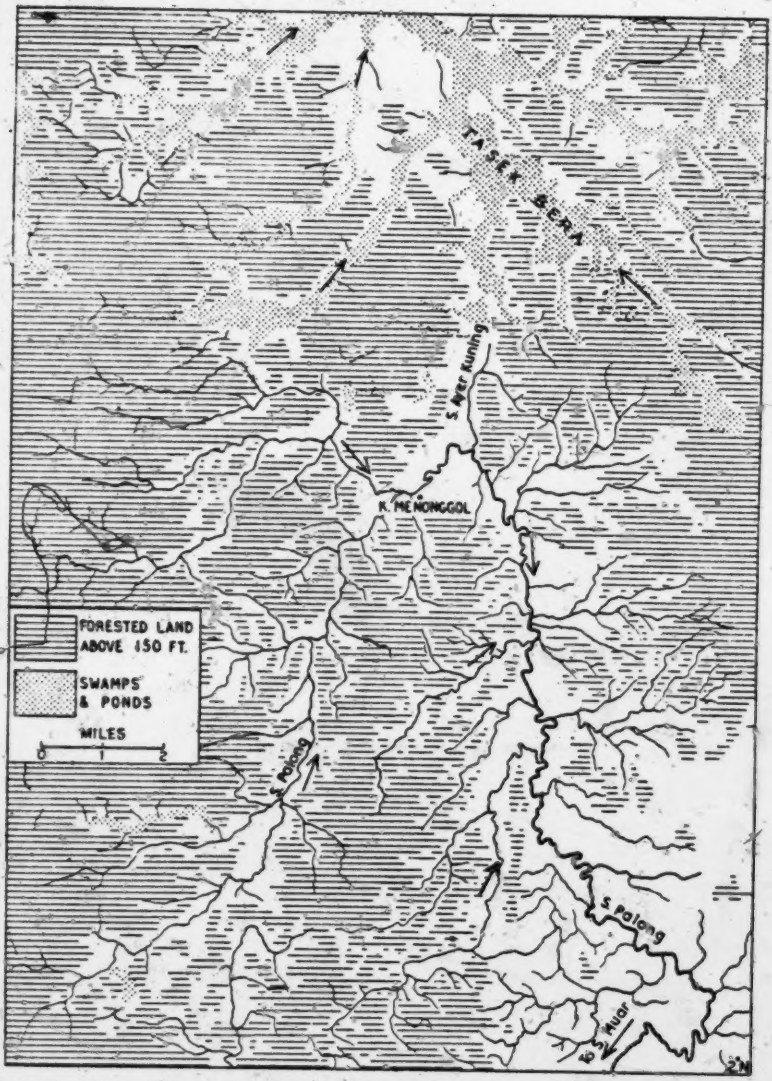

FIG. 16.—River Capture in Central Malaya. The Palong, tributary of the Muar, is drawing off headwaters of the Bera system

ago, at which time maximum water would be withdrawn from oceanic circulation and locked up as ice, thereby lowering the average sea level. Daly calculates that this withdrawal of water would mean a lowering of sea level (relative to present level) at the Equator by between 250 ft. and 300 ft. The average depth of

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133 water in the Sunda Platform seas today is 180 ft., so that on Daly's figures the whole Platform would be exposed and drainage lines developed upon it. Molengraaf's work (Fig. 18) suggests the drainage lines of the exposed Sunda continental surface formed two river systems flowing roughly north-eastwards from the Singapore area and roughly due east through what is now the [136] Java Sea. To support this conception he instances the striking likeness between fish of the Moesi in Sumatra and those of the Kapuas in Borneo and suggests the similarity derives from association through the main stream developed during the Glacial period. Because there have been in fact several glacial advances in northern latitudes (the Gunz, Mindel, Riss and Wurm Glaciation) his theory implies at least four periods of water withdrawal from the Sunda Platform (and of course from all equatorial areas): that is, four periods when the Sunda sea-floors were exposed to subaerial erosion.

Thus the broad history of recent river development has been one of periodical lowering of sea level, in effect a lowering of erosion base levels for all Sunda Platform rivers, which means four intervening periods of rejuvenation of Southeast Asia rivers and corresponding periods of rising sea level when rivers diminished their cutting power and became senescent, owing to rising erosional base level (Fig. 17). While the world glacial periods varied in duration, they appear not to have differed very widely in extent of greatest development, so that present sea level at the Equator probably represents roughly the level towards which the erosional base rose at each interglacial phase. Those early periods of rising sea could not, on present facts, have reached higher than 100 ft. above present sea level and it is almost certain the variation was much less. It is therefore difficult to accept any theorising which postulates during the last million years over the Sunda Platform sea level positions 100 ft. higher than the present one.

The landscapes carved by river systems over the older parts of Southeast Asia are conditioned in their recent forms by circumstances of a rising sea level, quite different from Europe and North America where a relatively rising land surface has had the latest influence on landscape form. A recent history of rising sea level implies:

(*a*) rising base levels to river erosion;

(*b*) diminution of downcutting power by existing streams;

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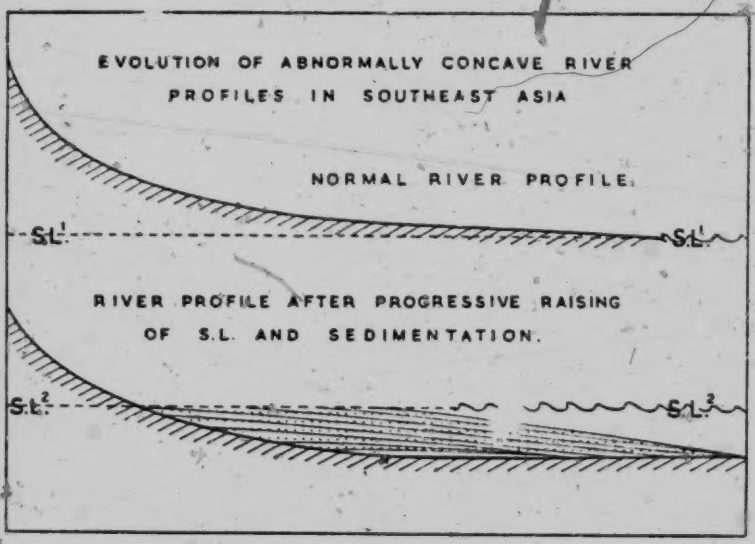

FIG. 17.—Diagram explaining the Development of Inselberge and Concave Profiles typical of the Sunda Platform

(*c*) diminution of load-carrying power and an increase of upstream sedimentation, due to loss of grade in the theoretical profiles;
(*d*) shallow offshore coastal profiles and consequent increase of coastal sedimentation;
(*e*) detrunking of streams as the inundation formed new marine gulfs (see Molengraaf);
(*f*) the rapid sedimentation of the estuaries produces in river profiles an abnormal flattening at lower levels while the upper profile retains the acute forms developed at lower sea level positions. This produces "sagging profiles," concave or flattened outlines (Fig. 17), as contrasted with kinked, faceted and convex profiles of contemporary streams in Europe;
(*g*) mountains in the form of "inselberge," that is, standing like islands surrounded by low-level alluvial plains.

During the glacial periods, when downcutting to a lower base level was the major influence, considerable upstream terraces could develop at all altitudes, but this aspect of Sunda Platform geography is difficult to study owing to the intensive weathering since that time and the heavy vegetation now masking any benches built or carved during the period. Such upstream terraces have been noted by Richardson and Scrivenor in Malaya.

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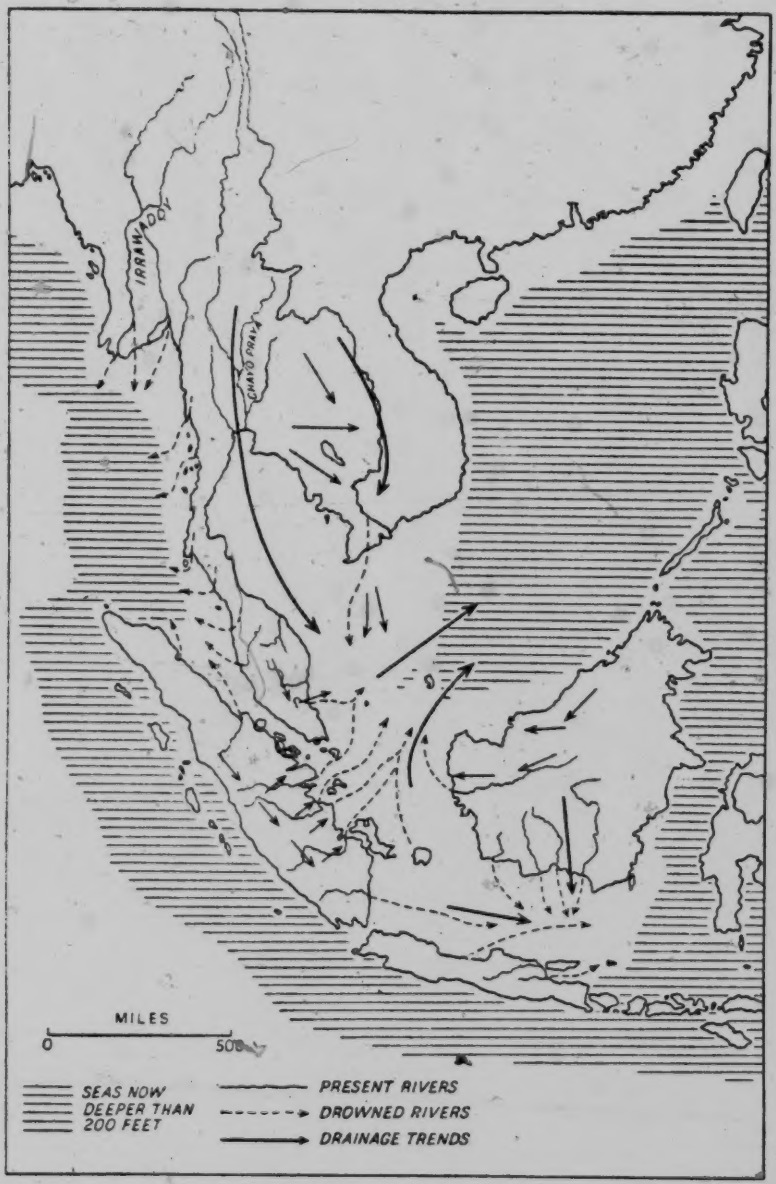

FIG. 18.—Drainage and Shallow Seas of Southeast Asia. Seas now shallower than 200 ft. were probably land areas in the Glacial Periods

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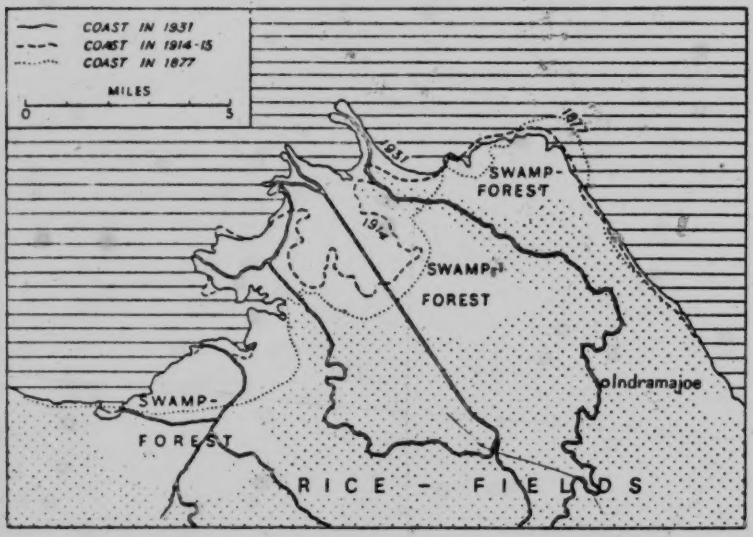

FIG. 19.—Coast Changes at the Mouth of R. Tjimanoek (Hoek van Indramajoe). This shows the rapid changes of the Java coast as a result of sedimentation

The history of inundation at first glance makes it surprising that ria forms have not appeared on the Sunda Platform; the explanation lies in the heavy sedimentation by the rivers and in the relatively soft laterised surface which would be presented to the rising sea and quickly moulded by it.

The glacial periods had little other effect in Southeast Asia; Weissman estimates the snow line in Northern Burma to have descended to about 9,000 ft. during the Glacial Periods. If this lowering of the snow line by about 3,500 ft. compared with today roughly indicates the condition for all Southeast Asia at the time of maximum glaciation, then in the equatorial zone where the present snowline is about 16,000 ft., no mountain tops of Borneo, Java, Sumatra and Malaya could have been seriously affected by snows, let alone by mountain glaciation. Interpretation of land forms in these units on the assumption of glaciation must therefore produce overwhelming evidence to counter such arguments.

SEDIMENTATION

Very heavy river loads, the decreasing carrying power of rivers, and the shallow seas of the Platform zone, combine to make rapid sedimentation of estuarial and coastal regions the characteristic

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of contemporary relief forms and drainage patterns. The rate of coastal advance seaward upon the Platform is in places phenomenally rapid; the Tjimanoek (Fig. 19) and Solo deltas in Java are extending at the rate of 100 metres annually, the Mekong at 60–80 metres annually. An outburst of volcanic ash increases the deposition by neighbouring rivers at the coast, though the behaviour of sea currents moulds the riberine deposit in detail on reaching the sea. Mangroves and associated vegetation quickly establish themselves on sandbanks and cays so that at the mouth of the Perak, for example, an exposure of a bank for only a few days at a low water season is enough to permit vegetation to start there, hastening the rate of deposition by offering an obstruction to river outflow and thereby perpetuating the bank which in other settings might disappear by erosion during the next high water spell.

Where streams debouch into deep seas the rate of coastal extension is inevitably less, due to the greater thicknesses which must be laid for every outward extension, yet the Irrawaddy Delta is building outward at the rate of about 60 metres per annum; that the Irrawaddy can maintain this rate of building into a deep basin reflects its tremendous load and a physical condition which concentrates the deposition of this load at the outer edge of the Delta rather than over its surface. (See Chapter 9.)

Because the rivers are steadily sedimenting the bed of their lower reaches, these are in fact generally being raised in level. Such a process cannot continue very far; when its bed is raised slightly above the surrounding land, the river easily changes course, and every large delta of Southeast Asia shows signs of frequent migration of distributaries. Old channels and distributaries in various phases of abandonment may be seen at nearly every river mouth. Most deltas suffer regular inundation at various times of the year facilitating farming for rice, which depends on either natural or artificially induced floods, in most cases derived from rivers. The process of spreading sediment over the whole delta zone goes on both by migration of distributaries and by seasonal inundations, so that the deltaic surface over a wide area is being slowly raised by sedimentation, making it progressively more difficult to irrigate the inner and higher sections of the deltas and in the long run causing the centre of gravity of irrigation steadily to move

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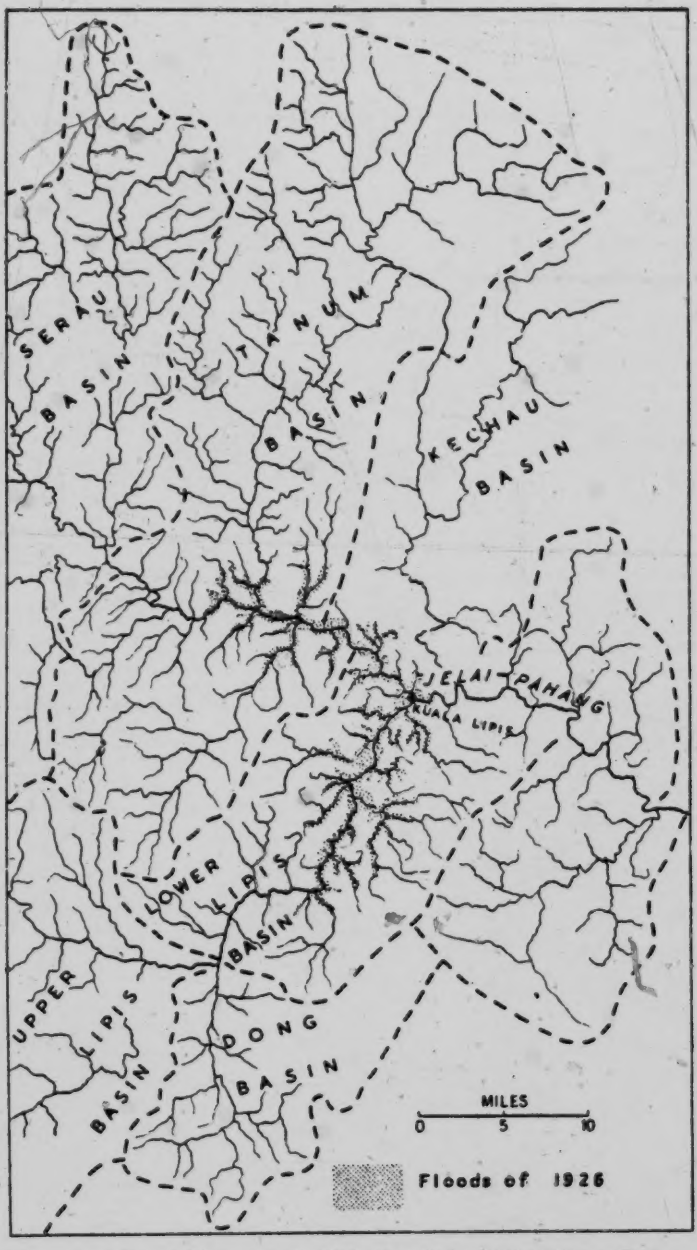

FIG. 20.—Flood Zones at the Junction of the Lipis-Pahang Rivers

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133 134 downstream, where also the newer unexhausted soils are to be found.

Marshes and Swamps

133 All land masses whose rivers empty on to the Sunda Platform are thus characteristically fringed with flat landscapes of marshes on a large scale. East Sumatra is an outstanding example of prolonged sedimentation by tropical rivers moving into shallow seas; this coastal marsh, at least 60,000 square miles in area, about a third of Sumatra, indicates what may result from equatorial sedimentation, here probably aided by a volcanic outburst in inner Sumatra during historic time (possibly during the century or so prior to A.D. 1000) and facilitated by the shallow Malacca Strait where the main tidal scour is to the east rather than to the Sumatra side. Huge flat islands have been formed off East Sumatra and they are regularly inundated by tides even now, so that they are in effect amphibious areas. The speed with which these coasts of sedimentation can advance and change should be taken into account when attempting to correlate historic place-names with sites and settlements of today. It may be that the decline of large principalities in Eastern Sumatra, reported in the first millennium by Oriental travellers, should be attributed to changes of coastline and to rapid deterioration of old site values.

Floods

A further feature of old drainage forms in Southeast Asia is the large size of inland swamps, as apparent in Malaya and Borneo. These arise from a combination of several factors:

(*a*) the torrential downpours are often so intense that for a few hours the surface water is greater than streams can carry off, or subsoil can absorb;

(*b*) the density of the vegetation cover impedes run-off;

(*c*) differences of downpours in nearby rivers frequently cause a swift rise of level in one stream and not in another which it joins, so that at the confluence (Fig. 20) the stream in spate dams back the other and the flood may even flow into it, or build bars of silt across it. The Tonle Sap marshes suffer from Mekong floods in this way;

(*d*) where a drainage system has cluse (as in Malayan streams) or similar constrictions (as in the Irrawaddy gorges) these features

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may induce flooding of the valley above the narrows. The Tasek Bera of Malaya in this way reflects constrictions in the Pahang Valley;

(*e*) the presence of levees means that the zone between them and the foothills has difficulty in draining to the river after a flood or during a downpour, so the levees are generally lined landwards by broad freshwater marshes, as by the rivers across the Korat Plateau in Siam (Fig. 90);

(*f*) where local rain seasons coincide with the arrival of spates, originating elsewhere in the local rivers, the landscape cannot shed the direct rainfall rapidly and it induces marshes.

Most of the freshwater marshes are seasonally flooded, drying out quickly in spells of drought, draining when local streams are low, but then flooding to depths up to 10 ft. during wet seasons.

Some types of swamp are man-induced. When alluvial mining is being carried on, dredges and gravel pumps effectively stir up large quantities of river sediment which is carried downstream as the mining effluent (Fig. 21).

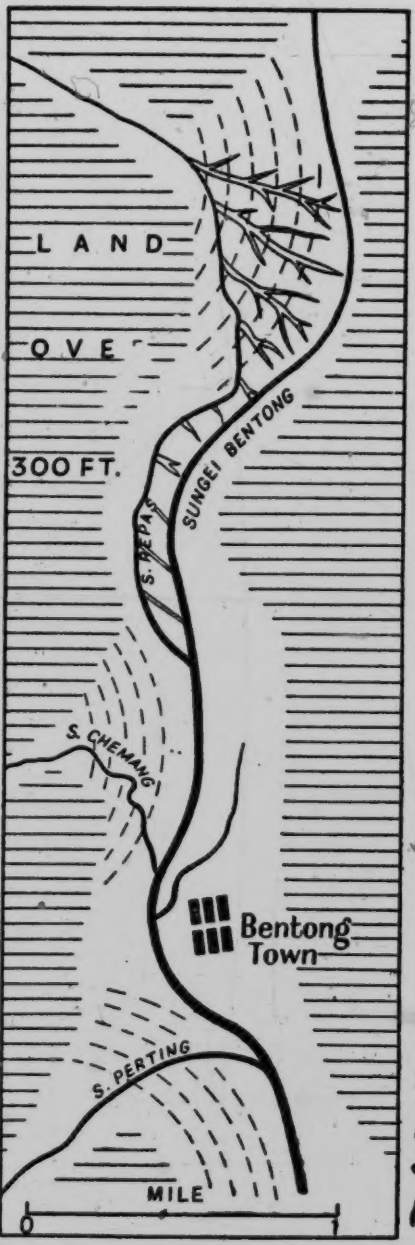

FIG. 21.—Alluvial Fans being thrust across Bentong Valley

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311 This artificially stirred sediment is agriculturally negative and
• 133 it penetrates the ditches and drains of rice growing areas,
241 gradually silting them up, often spectacularly raising the
134 local river bed (at Serendah in Malaya, the river bed was raised 21 ft. by sedimentation over the decade 1923-33), as well as sterilising fields on which the silt spreads so that cultivation becomes more difficult as the river can no longer be kept out. The yields decrease and the fields are abandoned, swamp vegetation gradually obliterating signs of cultivation. Round the lower Malacca River may be found signs of the old field bundings within the tangle of swamp vegetation now growing there, a sign of the effects of mining higher in the river whose effluent is obliterating cultivation in lower areas. This type of swamp comes slowly and has all the appearance of nature overcoming men's efforts to farm, but it is fundamentally a result of man-induced erosions or abrasions elsewhere. Thus interference, by mining and forest clearing, with landforms stabilised over long periods, not only goes on by removal of silt and gravels carried from mining areas and topsoils removed by torrential rains on clean-weeded agricultural areas as a mark of transfer of surface materials from one area, but it also causes the obliteration of cultivation and an extension of useless marsh in the areas where this material is deposited.

133 Because these tropical marshes occur in zones of human signifi-
361 cance, that is, in the flatter areas with agricultural possibilities, and along the coasts where settlement from overseas might take place, they have played a major part in conditioning the distribution of human beings in Southeast Asia. Both the coastal and inland marshes are tree-covered, making it even more difficult to penetrate, control, or cultivate them. Varying degrees of swampiness often account for the ease of development of farming in one place rather than another in Southeast Asia and a broad belt of marsh has generally proved a greater human impediment than any other topographic feature.

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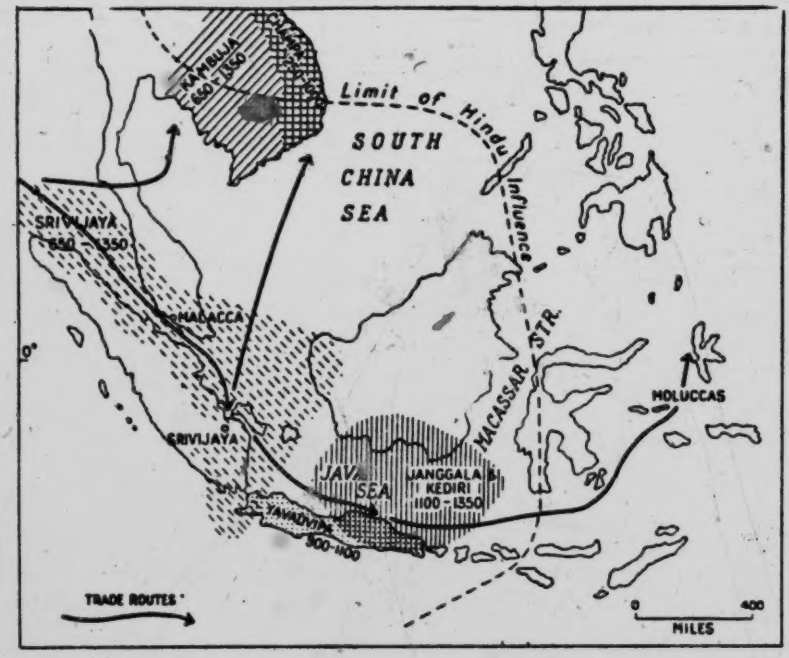

FIG. 113.—Historic Pattern of Southeast Asia during Indian Colonial Period

implements had not in any case developed far enough to deal with stone. Hence monumental evidence in Southeast Asia is so largely Indian, an introduction by foreigners using styles and techniques developed in their home settings, and most developed in the drier parts of this region, where stone is more accessible. On the clay lands, historic brick structures, also an Indian innovation, weather to nothing very quickly. At Angkor may be seen the power of quick-growing tropical trees to shatter and break down temples and palaces built of stone and lateritic blocks.

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This, too, is a region of natural calamities, difficult though it is to pin-point them. Little kingdoms have been wiped out in a few hours by Javanese volcanoes, as in A.D. 1006 when the flourishing city of Dharmavamsa (a great king of Central Java) was reduced to ashes by "a great calamity," probably an explosion and lava outflow of the Merapi volcano. Settlements along rivers have been obliterated when huge mud-flows swept down from loose ashes on the flanks of new eruptions, possibly accounting for our ignorance of east Sumatran kingdoms. Coasts have altered through the years

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and deltas have changed; areas which once were shallow sea have become sedimented to swamps, a process by which Cambodia has been cut off as the Lower Mekong built up mud-flats isolating Tonle Sap from contact with the sea. The evolution of new routes has caused some old centres of power to fade into mere fishing villages, evidenced in the decline of Takhola and Bandon after the sea route through the Straits of Malacca became more generally

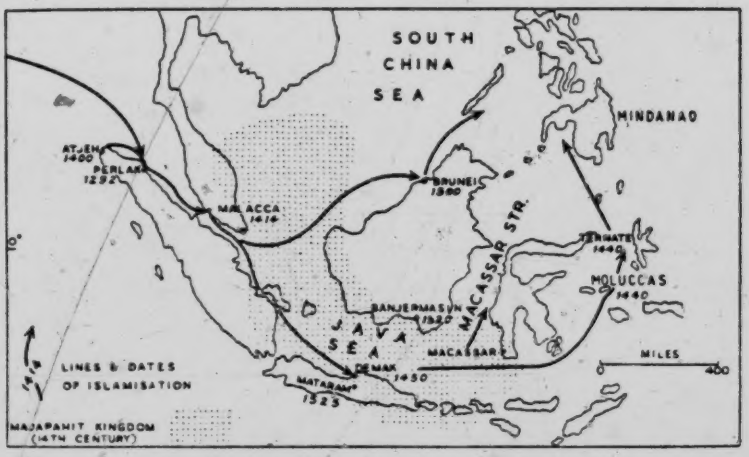

FIG. 114.—Historic Pattern of Southeast Asia at the Islamisation Period

used than that across Kra. Plagues have laid waste whole cities, as when Uthong in about 1350 was devastated by cholera and its population fled. The region is still one where malaria, dysentery, cholera and plague are endemic, more especially in the older, more congested territories like Java. These diseases have frequently flared up into appalling epidemics killing thousands of people, epidemics reflecting a relation between bacteria and the climate (which encourages bacterial reproduction), the population density, the difficulties of sewage disposal and social habits of indifference to hygiene (which has no ill effects among lonely settlements in the forest but becomes a social menace in towns). Fevers and virulent diseases have frequently ravaged the local people, debilitated them, and wiped out their settlements. The region is strewn with ruins of towns now abandoned, and with ruined groups of people who have degenerated physically by disease and under-nourishment. Southeast Asia proved capable of engulfing rather than enshrining those moving into it to live.